

REMARKS

Pursuant to the present amendment, claim 24 has been amended, claims 25-28 have been cancelled, and new claim 29 has been added. Thus, claims 1-24 and 29 are pending in the present application. No new matter has been introduced by way of the present amendment. Reconsideration of the present application is respectfully requested in view of the remarks set forth herein.

Pursuant to the present amendment, claims 25-28, which are directed to a non-elected invention, have been canceled. Applicants specifically reserve the right to pursue such claims in a later filed application should they so desire. Additionally, claim 24 has been amended to correct a typographical error as identified by the Examiner.

In the Office Action, claims 1-24 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over Licata (U.S. Patent No. 6,508,919). Applicants respectfully traverse the Examiner's rejections.

As the Examiner well knows, to establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. § 2142. Moreover, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (CCPA 1974). If an independent claim is nonobvious

under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); M.P.E.P. § 2143.03.

With respect to alleged obviousness, there must be something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561 (Fed. Cir. 1986). In fact, the absence of a suggestion to combine is dispositive in an obviousness determination. *Gambro Lundia AB v. Baxter Healthcare Corp.*, 110 F.3d 1573 (Fed. Cir. 1997). The mere fact that the prior art can be combined or modified does not make the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990); M.P.E.P. § 2143.01. The consistent criterion for determining obviousness is whether the prior art would have suggested to one of ordinary skill in the art that the process should be carried out and would have a reasonable likelihood of success, viewed in the light of the prior art. Both the suggestion and the expectation of success must be founded in the prior art, not in the Applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); *In re O'Farrell*, 853 F.2d 894 (Fed. Cir. 1988); M.P.E.P. § 2142.

Under these legal principles, it is respectfully submitted that all pending claims are in condition for allowance. By way of background, the method set forth in independent claim 1 requires, among other things, adjusting a direction of target atoms in a deposition ambient by ionizing a fraction of the target atoms, applying a bias voltage to the interconnect structure so as to predominantly deposit target ions on a bottom surface of the interconnect structure to form a bottom barrier layer, changing a composition of the deposition ambient while reducing the bias voltage to deposit a second barrier layer on the sidewalls of the interconnect structure,

substantially re-establishing the deposition ambient, and conformally depositing target atoms to form a third barrier layer over the bottom barrier layer and the second barrier layer.

As thus understood, it is respectfully submitted that independent claim 1 is not obvious in view of Licata. As understood by the undersigned, Licata is generally directed to the formation of liner films for dual damascene processing techniques. Col. 1, ll. 6-7. Licata notes that a first metal liner film, such as tantalum or titanium, may be applied to provide adhesion, low contact resistance and reduced contamination of the surrounding dielectric by the subsequently deposited overlying interconnect film or structure. Licata also notes that a second metal nitride liner film such as tantalum nitride, titanium nitride or tungsten nitride may be applied thereon to improve the barrier performance. Col. 1, ll. 15-23. Licata goes on to note that such liner films may be commonly deposited by conventional physical vapor deposition or chemical vapor deposition processes such as plasma enhanced chemical vapor deposition and thermal chemical vapor deposition. Col. 1, l. 36 – Col. 2, l. 11. Licata further notes that, in the context of forming various liners for dual damascene processing techniques, a balance must be struck between having enough diffusion barrier material to block the passage of diffusing atoms from the metal layer, the dielectric and the interconnect metal and having a thin enough layer to permit good electrical contact and cost-effective manufacturing. Col. 2, ll. 37-52. Licata goes on to note that good diffusion barrier properties are provided by utilizing a robust barrier material and by ensuring that sufficient barrier coverage is maintained along the entire feature surface. Good contact resistance is provided by distributing the barrier film thickness among at least one serial layer that is thin enough, and spaced by metal, to allow the passage of good electrical current by direct conduction or tunneling. Col. 3, ll. 20-27.

Licata provides several examples of liner stacks for use in damascene processing techniques. However, at no point does Licata disclose or suggest the methodology defined by independent claim 1. More specifically, at no point does Licata disclose or suggest the step of adjusting a direction of target atoms in a deposition ambient by ionizing a fraction of the target atoms, and applying a bias voltage to the interconnect structure so as to predominantly deposit target ions on a bottom surface of the interconnect structure to form a bottom barrier layer, or, thereafter, changing a composition of the deposition ambient while reducing the bias voltage to deposit a second barrier metal layer on the sidewalls of the interconnect structure. Licata also does not disclose the step of substantially re-establishing the deposition ambient and conformally depositing target atoms to form a third barrier layer over the bottom barrier layer and the second barrier layer. As understood by the undersigned, in each of the methodologies described in Licata, the initial bottom barrier layer is formed by a chemical vapor deposition process, either a thermal CVD process or a plasma enhanced CVD process. In fact, Licata notes that, for at least one example disclosed therein, the conformality achieved using the methodology described therein purports to be approximately two times better than conventional ionized PVD processing. Col. 5, ll. 19-20. Specifically, at no point does Licata disclose or suggest the step of changing a composition of the deposition ambient while reducing the bias voltage that was created to ionize target atoms used to form the bottom barrier layer on the bottom surface of interconnect structure. This methodology is simply not disclosed or even remotely suggested in Licata. It is respectfully submitted that any attempt to assert that the invention defined by independent claim 1 is obvious in view of Licata is based upon an improper use of hindsight using Applicants' disclosure as a roadmap.

It is also respectfully submitted that many of the dependent claims are also allowable over the art of record for reasons in addition to those set forth above with respect to claim 1 above. For example, dependent claim 3 recites that a fraction of the target atoms (used in forming the bottom barrier layer) are liberated from a sputter target. At no point does Licata disclose or suggest using a sputtering process to form the bottom barrier layer. Rather, in Licata, it appears that a chemical vapor deposition process, either plasma enhanced or a thermal CVD process, is employed in forming the bottom barrier layer. Thus, it is believed that dependent claim 3 is allowable over the art of record for at least this additional reasons.

Dependent claim 4 recites that the step of adjusting the direction of the target atoms includes controlling a pressure of the deposition atmosphere surrounding the target and the substrate. At no point does Licata even remotely suggest such a methodology. Similarly, claim 5 recites that the step of adjusting the direction of the target atoms includes controlling at least one of the substrate temperature and the geometry factor during the deposition of the target atoms. Again, Licata is simply silent with respect to this methodology.

Claims 6 and 7 recite further detailed process limitations with respect to the methodology set forth in claim 1. These limitations are nowhere disclosed or described in Licata.

Dependent claim 8 sets forth the additional step of re-sputtering a portion of the second barrier layer prior to depositing the third barrier layer. Respectfully, it is beyond legitimate dispute that Licata does not disclose this additional limitation. The concept of re-sputtering any layer is simply not disclosed in Licata, much less the re-sputtering of a portion of the second barrier layer prior to depositing the third barrier layer. Similar arguments apply equally with respect to dependent claim 12.

Thus, for at least the aforementioned reasons, it is respectfully submitted that claims 1-12 are in condition for immediate allowance.

New claim 29 has been added to further recite some specific materials for the various barrier layers identified in claim 1. For at least the reasons set forth above with respect to claim 1, it is respectfully submitted that dependent claim 29 is also in condition for allowance.

Independent claim 13 requires, among other things, the steps of forming a tantalum-based barrier layer by depositing tantalum by ionizing physical vapor deposition primarily at a bottom surface of a via formed in a dielectric layer of a metallization structure and depositing a tantalum nitride/tantalum bi-layer on sidewalls of the via. It is also respectfully submitted that this independent claim is allowable over the prior art of record. Specifically, Licata does not disclose or suggest depositing tantalum by ionizing physical vapor deposition primarily at a bottom surface of a via and thereafter depositing a tantalum nitride/tantalum bi-layer on the sidewalls of the via. As set forth previously, as understood by the undersigned, all of the bottom barrier layers in Licata are formed by either plasma enhanced or thermal chemical vapor deposition processes. Thus, it is respectfully submitted that independent claim 13, and all claims dependent therefrom, are in condition for immediate allowance.

It is also respectfully submitted that many of the claims dependent from claim 13 are allowable for independent reasons. For example, dependent claim 14 involves the step of applying a bias voltage to the metallization structure to direct tantalum atoms liberated from a sputter target substantially perpendicularly to the bottom surface. Since Licata does not disclose an ionizing physical vapor deposition process for formation of the bottom barrier layer, it necessarily does not disclose the limitations set forth in claim 14.

It is also respectfully submitted that Licata does not disclose the limitations set forth in claims 15 and 16 for controlling various parameters of the physical vapor deposition process cited in claim 13.

Additionally, the detailed process requirements set forth in claims 17 and 18 are likewise not disclosed in Licata.

Dependent claim 19 requires the step of re-sputtering a portion of the tantalum atoms prior to depositing a tantalum nitride/tantalum bi-layer. As set forth above with respect to dependent claim 8, the concept of re-sputtering any layer is simply not disclosed or suggested in Licata. Thus, it is respectfully submitted that dependent claim 19 is allowable over the art of record.

Dependent claim 22 further recites that the tantalum nitride/tantalum bi-layer is deposited by ion physical vapor deposition. Licata simply does not disclose this methodology. In fact, if anything, Licata can be said to teach away from this limitation. See, *e.g.*, Col. 5, ll. 13-20.

Dependent claim 23 recites that the tantalum ions and the tantalum nitride/tantalum bi-layer are deposited in a common process chamber without breaking a vacuum established therein. Nowhere is this even remotely suggested by the disclosure of Licata.

Lastly, it is also submitted that dependent claim 24 is allowable as it is directed to re-sputtering a portion of the tantalum ions deposited on the bottom surface of the trench prior to depositing the tantalum nitride/tantalum bi-layer. As set forth above, the concept of re-sputtering any layer is simply not disclosed or suggested in Licata.

It is respectfully submitted that a full and fair reading of the disclosure of Licata leads to the conclusion that the obviousness rejections set forth in the Office Action should be withdrawn. It is further respectfully submitted that any attempt to assert that the inventions

defined by the pending claims are obvious in view of Licata is necessarily based upon an improper use of hindsight using Applicants' disclosure as a roadmap. A recent Federal Circuit case makes it crystal clear that, in an obviousness situation, the prior art must disclose each and every element of the claimed invention, and that any motivation to combine or modify the prior art must be based upon a suggestion in the prior art. *In re Lee*, 61 U.S.P.Q.2d 143 (Fed. Cir. 2002). Conclusory statements regarding common knowledge and common sense are insufficient to support a finding of obviousness. *Id.* at 1434-35.

In view of the foregoing, it is respectfully submitted that all pending claims are in condition for allowance. The Examiner is invited to contact the undersigned attorney at (713) 934-4055 with any questions, comments or suggestions relating to the referenced patent application.

Respectfully submitted,

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